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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference: 6328YT

For further action:

See Notification of Transmittal of International Preliminary Examination Report

(From PCT/IPEA/416)

International application No.: PCT/JP03/11018

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Applicant: YOKOHAMA TLO COMPANY, Ltd.

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

x This REPORT is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 14 sheets.

3. This REPORT is also accompanied by following items.

- x Basis of the report
- x Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

Date of submission of the demand: 02 June 2004(02.06.2004)
Date of completion of this report: 02 July 2004 (02.07.2004)

International Preliminary Examination Report

International application No.
PCT/JP03/11018

I. Basis of the report

2. This report has been drawn on the basis of the following documents. Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments.

x specification :

- pages 2, 8, 10-15, as originally filed,
- pages 1, 3, 3/1, 4-7, 9, 16, filed with the demand

x claims:

- claim Nos. 1-9, filed with the demand

x drawings:

- Figs. 1-5, as originally filed.

2-5. (Omitted)

V. Reasoned statement under Article 35 (2) with respect to novelty, inventive step or industrial applicability; citations and explanations supporting such statement:

1. STATEMENT:

Novelty (N)	Claims 1-9	YES
Inventive step (IS)	Claims 1-9	YES
Industrial Applicability(IA)	Claims 1-9	YES

2. CITATIONS AND EXPLANATIONS (PCT Rule 70.7):

Document 1: Simulation of a High-Efficiency Radio Frequency Use System by Means of Multipath Characteristic Matrix on Time Spread Signals (Keisuke Higuma, Naoki Suehiro,

Toshiaki Imoto, and Noriyoshi Kuroyanagi), Technical Journal of The Institute of Electronics, Information and Communication Engineers, 22 June, 2001 (22.06.01), Vol.101, No.128, SST2001-20, pages 21-27

Document 2: Polyphase Complementary Codes, (Robert L. Frank), IEEE Transactions on Information Theory, November 1980, Vol. IT-26, No.6.

The subject matters of claims 1-9 are not disclosed in any of the documents cited in the ISR, and so appear to be novel and to involve an inventive step.

AMENDMENT

(Amendment under Article 11 of the Law)

June 2, 2004

To: Examiner of the Patent Office

1. International Application No. : PCT/JP03/11018

2. Applicant:

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4. Object of Amendment

Specification and Claim

5. Contents of Amendment

(1) "TRANSMISSION SIGNAL PRODUCTION METHOD" in the 4th line in page 1 of the specification is amended to "TRANSMISSION METHOD".

(2) "production method, a communication method using the

transmission signal" in the 10-11th lines in page 1 of the specification is amended to "transmission method, a communication method".

(3) "transmission data sequence" in the 10th line in page 4 of the specification is amended to "data sequence".

(4) "In a first mode of the transmission signal production method …… to produce a transmission data sequence." from the 21st line in page 4 to the 11th line in page 5 of the specification is amended to "In a first mode of the transmission method according to the present invention,

a plurality of finite-length signals of a length Nm

$S_{A,X}=(x_0A,\ 0\cdots0,\ x_1A,\ 0\cdots0,\ x_2A,\ 0\cdots0,\ \cdots,\ x_{m-1}A,\ 0\cdots0)$

$S_{B,Y}=(y_0B,\ 0\cdots0,\ y_1B,\ 0\cdots0,\ y_2B,\ 0\cdots0,\ \cdots,\ y_{m-1}B,\ 0\cdots0)$

…

are created using a plurality of data sequences

$A=(a_0a_1\cdots a_{N-1})$, $B=(b_0b_1\cdots b_{N-1})$, … and

a plurality of coefficient sequences

$X=(x_0x_1\cdots x_{m-1})$, $Y=(y_0y_1\cdots y_{m-1})$, …;

each finite-length signal of the finite-length signals $S_{A,X}$, $S_{B,Y}$, … is repeated to produce a pseudo periodic signal …, $S_{A,X}$, $S_{A,X}$, $S_{A,X}$ …, …, $S_{B,Y}$, $S_{B,Y}$, $S_{B,Y}$, …, …; and a part is cut out from this pseudo periodic signal to produce a signal of a predetermined length for making this signal a transmission signal.

In a second mode of the transmission method according to the present invention, a plurality of signals of a predetermined length, cut out from the pseudo periodic signal produced from different finite-length signals, are added up to make the added-up signal to produce a transmission signal".

(5) "transmission data" in the 12th in page 5 of the

specification is amended to "a data sequence".

(6) "transmission signal production method" in the 14-15th lines in page 5 of the specification is amended to "transmission method".

(7) "second mode of the transmission signal production ..... a transmission data sequence" in the 17-19th lines in page 5 of the specification is amended to "second mode described above is used for producing a transmission signal".

(8) "transmission data sequences" in the 16th, 20-21st, 22nd, 23-24th and 25th lines in page 5 of the specification is amended to "transmission signals".

(9) "transmission signal production method" in the 27th line in page 6 and the 4-5th lines in page 8 of the specification is amended to "transmission method".

(10) "transmission data sequence" in the 26th and 30th lines in page 6 and the 1st, 6-7th and 9th lines in page 7 of the specification is amended to "transmission signal".

(11) "transmission data" in the 28th line in page 6 of the specification is amended to "a data sequence".

(12) "transmission data sequences used as transmission signals" in the 10-11th lines in page 7 of the specification is amended to "transmission signals used as the transmission signals for transmitting information".

(13) "transmission signal" in the 14th line in page 7 of the specification is amended to "other transmission signals".

(14) "a transmission data sequence ..... an infinite number of times." from the 25th to 31st lines in page 7 of the specification is amended to "a signal of a predetermined length produced in accordance with a method comprising the steps of producing a plurality of finite-length signals of

a length Nm $S_{A,X}=(x_0A, 0\ldots0, x_1A, 0\ldots0, x_2A, 0\ldots0, \ldots, x_{m-1}A, 0\ldots0)$, $S_{B,Y}=(y_0B, 0\ldots0, y_1B, 0\ldots0, y_2B, 0\ldots0, \ldots, y_{m-1}B, 0\ldots0)$, ... using a plurality of data sequences $A=(a_0a_1\ldots a_{N-1})$, $B=(b_0b_1\ldots b_{N-1})$, ... and a plurality of coefficient sequences $X=(x_0x_1\ldots x_{m-1})$, $Y=(y_0y_1\ldots y_{m-1})$, ...; repeating each finite-length signal of the finite-length signals S_{AX}, S_{BY}, ... to produce a pseudo periodic signal ..., $S_{A,X}$, $S_{A,X}$, $S_{A,X}$ ..., ..., $S_{B,Y}$, $S_{B,Y}$, $S_{B,Y}$, ..., ...; and cutting out a part from this pseudo periodic signal."

(15) "transmission data" in the 30-31st lines in page 8 and the 4-5th, 7th, 8th and 17th lines in page 9 of the specification is amended to "data sequence".

(16) "transmission data sequence" in the 29-30th lines in page 8 and the 11-12th lines in page 9 of the specification is amended to "transmission signal".

(17) "this transmission data sequence is used as a transmission signal" in the 2-3rd lines in page 9 of the specification is amended to "is used as a transmission signal".

(18) "transmission data sequence B" in the 6th line in page 9 of the specification is amended to "transmission signal B".

(19) "transmission data" in the 18th, 19th, 21st and 27-28th lines in page 9 of the specification is amended to "transmission signal".

(20) "transmission data" in the 22nd line in page 9 and 17th and 20th lines in page 10 of the specification is amended to "data sequence".

(21) "transmission data" in the 4th and 6th lines in page 12 of the specification is amended to "transmission signal".

(22) "transmission signal production method" in the 20th line in page 19 of the specification is amended to

"transmission method".

(23) "advantageous and are useful for" in the 23rd line in page 19 of the specification is amended to "advantageous to and useful for".

(24) "A transmission signal production method ..... a transmission data sequence" in claim 1 in page 20 of the claim is amended to "A transmission method comprising the steps of:

producing a plurality of finite-length signals of a length Nm

$S_{A,X}=(x_0A,\ 0\ldots0,\ x_1A,\ 0\ldots0,\ x_2A,\ 0\ldots0,\ \ldots,\ x_{m-1}A,\ 0\ldots0)$

$S_{B,Y}=(y_0B,\ 0\ldots0,\ y_1B,\ 0\ldots0,\ y_2B,\ 0\ldots0,\ \ldots,\ y_{m-1}B,\ 0\ldots0)$

...

using a plurality of data sequences

$A=(a_0a_1\ldots a_{N-1})$, $B=(b_0b_1\ldots b_{N-1})$, ... and

a plurality of coefficient sequences

$X=(x_0x_1\ldots x_{m-1})$, $Y=(y_0y_1\ldots y_{m-1})$, ...;

repeating each finite-length signal of said finite-length signals $S_{A,X}$, $S_{B,Y}$, ... to produce a pseudo periodic signal ..., $S_{A,X}$, $S_{A,X}$, $S_{A,X}$ ..., ..., $S_{B,Y}$, $S_{B,Y}$, $S_{B,Y}$, ..., ...; and

cutting out a part from said pseudo periodic signal to produce a signal of a predetermined length longer than Nm for making said signal a transmission signal."

(25) "A transmission signal production method ..... a transmission data sequence" in claim 2 in page 20 of the claim is amended to "The transmission method according to claim 1, further comprising the step of adding up a plurality of signals of a predetermined length, cut out from the pseudo periodic signal produced from different finite-length signals, to produce a transmission signal."

(26) "transmission signal production method" is amended to

"transmission method" and "transmission data sequences" is amended to "transmission signals" in claim 3 in page 20 of the claim.

(27) "transmission signal production method" is amended to "transmission method" and "transmission data sequence" is amended to "transmission signal" in claim 4 in pages 20-21 of the claim.

(28) "transmission signal production method" in claim 5 in page 21 of the claim is amended to "transmission method."

(29) "transmission data sequence" is amended to "transmission signal" and "receiving …… coefficient sequence" is amended to "receiving said transmission signal and outputting a data sequence via a matched filter corresponding to said coefficient sequence" in claim 6 in page 21 of the claim.

(30) "transmission data sequence" in claim 7 in page 21 of the claim is amended to "at least one transmission signal selected from said transmission signals."

(31) "transmission data sequence" is amended to "transmission signal", "with other transmission data sequences used as transmission signals" is deleted, and "transmission data" is amended to "data sequence" in claim 8 in pages 21-22 of the claim.

(32) "A data structure …… an infinite number of times" in claim 9 in page 22 of the claim is amended to "A data structure of a transmission signal comprising a signal of a predetermined length produced in accordance with a method comprising the steps of:

producing a plurality of finite-length signals of a length Nm

$S_{A,X}=(x_0A,\ 0\ldots0,\ x_1A,\ 0\ldots0,\ x_2A,\ 0\ldots0,\ \ldots,\ x_{m-1}A,\ 0\ldots0)$

$S_{B,Y}=(y_0B, 0\ldots0, y_1B, 0\ldots0, y_2B, 0\ldots0, \ldots, y_{m-1}B, 0\ldots0)$

…

using a plurality of data sequences

$A=(a_0a_1\ldots a_{N-1})$, $B=(b_0b_1\ldots b_{N-1})$, … and

a plurality of coefficient sequences

$X=(x_0x_1\ldots x_{m-1})$, $Y=(y_0y_1\ldots y_{m-1})$, …;

repeating each finite-length signal of said finite-length signals $S_{A,X}$, $S_{B,Y}$, … to produce a pseudo periodic signal …, $S_{A,X}$, $S_{A,X}$, $S_{A,X}$ …, …, $S_{B,Y}$, $S_{B,Y}$, $S_{B,Y}$, …, …; and

cutting out a part from said pseudo periodic signal."

6. List of Attached Documents

AMENDMENT

(Amendment under Article 11 of the Law)

June 2, 2004

To: Examiner of the Patent Office

1. International Application No. : PCT/JP03/11018

2. Applicant:

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Fujisawa-shi, Kanagawa 251-0024 Japan

4. Object of Amendment

Specification and Claim

5. Contents of Amendment

(1) "TRANSMISSION SIGNAL PRODUCTION METHOD" in the 3rd line in page 1 of the specification is amended to "TRANSMISSION METHOD".

(2) "production method, a communication method using the

transmission signal" in the 6th line in page 1 of the specification is amended to "transmission method, a communication method".

(3) "transmission data sequence" in the 11th line in page 3 of the specification is amended to "data sequence".

(4) "In a first mode of the transmission signal production method ..... to produce a transmission data sequence." from the 19th in page 3 to the 2nd line in page 4 of the specification is amended to "In a first mode of the transmission method ..... to produce a transmission signal".

(5) "transmission data" in the 3rd in page 4 of the specification is amended to "a data sequence".

(6) "transmission signal production method" in the 5th line in page 4 of the specification is amended to "transmission method".

(7) "second mode of the transmission signal production ..... a transmission data sequence" in the 6th line in page 4 of the specification is amended to "second mode described above is used for producing a transmission signal".

(8) "transmission data sequence" in the 6th, 7th, 8th, 10th, and 11th lines in page 4 of the specification is amended to "transmission signal".

(9) "transmission signal production method" in the 2nd and 25th lines in page 5 of the specification is amended to "transmission method".

(10) "transmission data sequence" in the 2nd, 3rd, 5th, and 9th lines in page 5 of the specification is amended to "transmission signal".

(11) "transmission data" in the 4th line in page 5 of the specification is amended to "a data sequence".

(12) "transmission data sequences used as transmission

signals" in the 10th line in page 5 of the specification is amended to "transmission signals used as the transmission signals for transmitting information".

(13) "transmission signal" in the 12th line in page 5 of the specification is amended to "other transmission signals".

(14) "a transmission data sequence …… an infinite number of times." in the 19th to 21st lines in page 5 of the specification is amended to "a signal of a predetermined length …… pseudo periodic signal."

(15) "transmission data" in the 15th, 18th, 19th, 20th, and 26th lines in page 6 of the specification is amended to "data sequence".

(16) "transmission data sequence" in the 16th and 22nd lines in page 6 of the specification is amended to "transmission signal".

(17) "this transmission data sequence is used as a transmission signal" in the 17th line in page 6 of the specification is amended to "is used as a transmission signal".

(18) "transmission data sequence B" in the 20th line in page 6 of the specification is amended to "transmission signal B".

(19) "transmission data" in the 1st, 3rd, 4th, and 9th lines in page 7 of the specification is amended to "transmission signal".

(20) "transmission data" in the 5th and 25th lines in page 7 of the specification is amended to "data sequence".

(21) "transmission data" in the 12th and 13th lines in page 9 of the specification is amended to "transmission signal".

(22) "transmission signal production method" in the 10th

line in page 16 of the specification is amended to "transmission method".

(23) "advantageous and are useful for" in the 11th line in page 16 of the specification is amended to "advantageous to and useful for".

(24) "A transmission signal production method …… a transmission data sequence" in claim 1 in page 17 of the claim is amended to "A transmission method …… a transmission signal."

(25) "A transmission signal production method …… a transmission data sequence" in claim 2 in page 17 of the claim is amended to "The transmission method …… a transmission signal."

(26) "transmission data sequences" is amended to "transmission signals" and "transmission signal production method" is amended to "transmission method" in claim 3 in page 17 of the claim.

(27) "transmission data sequence" is amended to "transmission signal" and "transmission signal production method" is amended to "transmission method" in claim 4 in page 17 of the claim.

(28) "transmission signal production method" in claim 5 in page 17 of the claim is amended to "transmission method."

(29) "transmission data sequence" is amended to "transmission signal" and "receiving …… coefficient sequence" is amended to "receiving said transmission signal and outputting …… coefficient sequence" in claim 6 in page 17 of the claim.

(30) "transmission data sequence" in claim 7 in page 17 of the claim is amended to "at least one transmission signal selected from said transmission signals."

(31) "transmission data sequence" is amended to "transmission signal", "with other transmission data sequences used as transmission signals" is deleted, and "transmission data" is amended to "data sequence" in claim 8 in page 18 of the claim.
(32) "A data structure …… an infinite number of times" in claim 9 in page 18 of the claim is amended to "A data structure …… said pseudo periodic signal."

6. List of Attached Documents
(1) Page 1 of specification
(2) Pages 3 and 3/1 of specification
(3) Page 4 of specification
(4) Pages 5 and 5/1 of specification
(5) Page 6 of specification
(6) Page 7 of specification
(7) Page 9 of specification
(8) Page 16 of specification
(9) Pages 17 and 17/1 of claim
(10) Pages 18 and 18/1 of claim

==PAGE 1==

SPECIFICATION

TRANSMISSION METHOD, COMMUNICATION METHOD, AND DATA STRUCTURE OF TRANSMISSION SIGNAL

TECHNICAL FIELD

The present invention relates to a transmission method, a communication method, and a data structure of the transmission signal and, more particularly, is advantageous to a multi-path environment such as that of mobile communication.

BACKGROUND ART

As a demand for data communication is increased in cellular wireless communication and various mobile environments, there is a need for a technology that increases the utilization of wireless frequency resources. For example, in the communication method using the CDMA method, the correlation characteristics of a spreading sequence and the inter-channel interference due to the multi-path characteristics of a transmission path are factors that limit the frequency utilization.

Because the method using Orthogonal Frequency Division Multiplexing (OFDM) is frequency multiplexing using a sine wave, the effect of a multi-path appears as the fading of a signal power and, therefore, there is a problem that it is difficult to separate a transmitted sine wave signal from a multi-path sine wave signal.

On the other hand, the CDMA method can use a pilot signal to separate a transmission signal from a multi-path signal transmitted at the same frequency and at the same time.

The CDMA method is a multiple access method using the spread spectrum communication method. In this spread spectrum communication method, modulation is performed using a spreading code sequence. For example, a periodic sequence with no autocorrelation is used as the spreading code sequence.

As a spreading code sequence that separates the original transmission signal from a multi-path signal, a

==page 3==
linearity part of the amplifier increases the power consumption of the amplifier. An increase in the power consumption results in a decrease in the standby time of a mobile terminal.

In view of the foregoing, it is an object of the present invention to solve the conventional problems described above, to reduce an increase in the amplitude of the signal during the modulation of transmission data through spread spectrum, and to reduce the dynamic range of an amplifier on the receiving side.

DISCLOSURE OF THE INVENTION

When transmission data is modulated via spread spectrum, a spreading sequence itself is processed in the prior art to make the periodic spectrum of a transmission signal a non-correlated spectrum. By contrast, when transmission data is modulated via spread spectrum according to the present invention, not the spreading sequence itself is processed as in the prior art but a data sequence is processed to make the periodic spectrum of the transmission signal a non-correlated spectrum. Making the periodic spectrum of the transmission signal a non-correlated spectrum reduces an increase in the amplitude of a signal and reduces the dynamic range of an amplifier on the receiving side.

The method according to the present invention includes transmission data into a spreading sequence to allow a whole signal, which includes the data, to function as a spreading sequence, thereby reducing the dynamic range load.

In a first mode of the transmission method according

to the present invention,

a plurality of finite-length signals of a length Nm

$S_{A,X}=(x_0A,\ 0\ldots0,\ x_1A,\ 0\ldots0,\ x_2A,\ 0\ldots0,\ \ldots,\ x_{m-1}A,\ 0\ldots0)$

$S_{B,X}=(y_0B,\ 0\ldots0,\ y_1B,\ 0\ldots0,\ y_2B,\ 0\ldots0,\ \ldots,\ y_{m-1}B,\ 0\ldots0)$

...

==page 3/1==

are created using a plurality of data sequences

$A=(a_0a_1\cdots a_{N-1})$, $B=(b_0b_1\cdots b_{N-1})$, ... and

a plurality of coefficient sequences

$X=(x_0x_1\cdots x_{m-1})$, $Y=(y_0y_1\cdots y_{m-1})$, ...;

each finite-length signal of the finite-length signals $S_{A,X}$, $S_{B,Y}$, ... is repeated to produce a pseudo periodic signal ..., $S_{A,X}$, $S_{A,X}$, $S_{A,X}$ ..., ..., $S_{B,Y}$, $S_{B,Y}$, $S_{B,Y}$, ..., ...; and a part is cut out from this pseudo periodic signal to produce a signal of a predetermined length for making this signal a transmission signal.

In a second mode of the transmission method according to the present invention, a plurality of signals of a predetermined length, cut out from the pseudo periodic signal produced from different finite-length signals, are added up to make the added-up signal to produce a transmission signal.

==page 4==

In the first or second mode of transmission signal production described above, a data sequence is included into the spreading sequence.

In another mode of the transmission method according to the present invention, a plurality of transmission signals are produced using different coefficient sequences when the first or second mode described above is used for producing a transmission signal and, in an arbitrary combination of two different transmission signals, a periodic cross-coefficient function of the transmission data of the transmission signals is 0 for all shifts. The plurality of transmission signals are transmitted in parallel so that the periodic spectrums of the transmission signals have no correlation.

The coefficient sequence used for the transmission signal production according to the present invention can be selected from a ZCZ sequence, can be a coefficient sequence of any vector row selected from a complete complementary sequence, and can be produced using a DFT matrix.

The ZCZ sequence used here is a sequence having a periodic zero correlation zone that has the zero auto-correlation zone characteristics and zero cross-correlation zone characteristics. For example, a complete complementary sequence can be used as the predetermined coefficient sequence. A complete complementary sequence is a sequence having the auto-correlation characteristics where the sum of the auto-correlation function of the sequences is 0 for all shifts except 0 shift and the cross-correlation characteristics where the sum of the cross-correlation function of the

sequences is always 0 for all shifts.

A DFT matrix is a discrete Fourier transform matrix and is a square matrix having orthonormal columns. The nature of different rows of a DFT matrix is that the periodic cross-correlation function is zero for all shifts and, therefore, the periodic cross function of the signals, produced using different rows of a DFT matrix using this nature of the DFT matrix, can have the value of zero for all shifts. The present invention uses this nature of a DFT matrix to allow a plurality of signals to be transmitted

==page 5==
at the same time without causing a mutual interference among periodic signals.

The communication method according to the present invention comprises the steps of transmitting the transmission signal produced in accordance with the transmission method of the present invention and receiving a data sequence via a matched filter corresponding to the coefficient sequence used for the production of the transmission signal.

According to the communication method of the present invention, the transmission signal is used as a pilot signal for measuring multi-path characteristics, and the multi-path characteristics of a transmission path can be obtained by receiving this pilot signal.

In another mode of the communication method of the present invention, a plurality of transmission signals are produced using different coefficient sequences and at least one transmission data sequence selected from the transmission signals is used as the pilot signal with other transmission signals used as the transmission signals for transmitting information. The multi-path characteristics are obtained from the reception signal of the pilot signal, and the multi-path characteristics are removed from the reception signal of the other transmission signals using the multi-path characteristics, which are found, to produce transmission data.

The periodic spectrums of the pilot signal and the transmission signals have no correlation and, by passing them thorough the corresponding matched filters, each signal can be separated. The multi-path characteristics of the

pilot signal can be obtained from the relation between the transmission signal and the reception signal, and the transmission signals can be obtained from the multi-path characteristics and the reception signals.

The data structure of a transmission signal according to the present invention comprises a signal of a predetermined length produced in accordance with a method comprising the steps of producing a plurality of finite-length signals of a length Nm $S_{A,X}=(x_0A, 0\ldots0, x_1A, 0\ldots0, x_2A, 0\ldots0, \ldots, x_{m-1}A, 0\ldots0)$, $S_{B,X}=(y_0B, 0\ldots0, y_1B, 0\ldots0, y_2B, 0\ldots0, \ldots, y_{m-1}B, 0\ldots0)$, ... using a plurality of data sequences $A=(a_0a_1\ldots a_{N-1})$, $B=(b_0b_1\ldots b_{N-1})$, ... and a plurality of coefficient sequences $X=(x_0x_1\ldots x_{m-1})$, $Y=(y_0y_1\ldots y_{m-1})$, ...; repeating each finite-length signal of the finite-length signals S_{AX}, S_{BY}, ... to produce a pseudo periodic

==page 5/1==

signal …, $S_{A,X}$, $S_{A,X}$, $S_{A,X}$ …, …, $S_{B,Y}$, $S_{B,Y}$, $S_{B,Y}$, …, …; and cutting out a part from this pseudo periodic signal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a general diagram showing a transmission method according to the present invention and the data structure of a transmission signal according to the present invention; FIG. 2 is a diagram showing the coefficients of

==page 6==

a fourth order DFT matrix; FIG. 3 is a diagram showing the relation between a pilot signal and transmission signals; FIG. 4 is a diagram showing the relation and correlation between transmission signals and detected signals; and FIG. 5 is a diagram showing an example of a signal that uses a complete complementary sequence as the spreading code sequence.

BEST MODE FOR CARRYING OUT THE INVENTION

A transmission signal production method, a communication method, and the data structure of a transmission signal in the best mode for carrying out the present invention will be described below with reference to the drawings.

The following describes embodiments of the present invention in detail with reference to the drawings.

FIG. 1 is a general diagram showing a transmission signal production method of the present invention and the data structure of a transmission signal of the present invention.

According to the present invention, a transmission signal (shown in FIG. 1(c, d)) is produced from a data sequence b (=(b0, b1, b2, b3, …, bM-1)) (shown in FIG. 1(a)) using a spreading sequence (sequence a(= (a0, a1, …, aN-1) in FIG. 1(b)), and is used as a transmission signal. The length of the spreading sequence is N bits, and the data length of the data sequence b is M bits.

To produce the transmission signal B from the data sequence b (b0, b1, b2, b3, …, bM-1) (shown in FIG. 1(a)),

the data sequence (b0, b1, b2, b3, …, bM-1) is multiplied by the coefficients of the coefficient sequence (a0, a1, …, aN-1) of the predetermined spreading sequence (shown in FIG. 1(b)) to produce a plurality of transmission signals B0, B1, …,BM-1.

FIG. 1 shows an example of the coefficient sequence (a0, a1, … , aN-1) of a spreading sequence, that is, (1, 0, …, 0, j, 0, …, 0, -1, 0, …, 0, -j, 0, …, 0). When the coefficient sequence of this spreading sequence is applied

==page 7==

to the data sequence b (b0, b1, b2, b3, …, bM-1), transmission signal B0 becomes (b0, 0, …, 0, jb0, 0, …, 0, -b0, 0, …, 0, -jb0, 0, …, 0) and transmission signal B1 becomes (b1, 0, …, 0, jb1, 0, …, 0, -b1, 0, …,0, -jb1, 0, …, 0). The other transmission signals are also processed in the same manner. The processing in which the data sequence b (=(b0, b1, b2, b3, …, bN-1)) is multiplied by the coefficients of the coefficient sequence(a0, a1, …, aN-1) of the predetermined spreading sequence is represented by the Kronecker product as shown in FIG. 1(b).

Next, as shown in FIG. 1(c), a plurality of transmission signals B0, B1, B2, … , produced by multiplying them by the coefficients, are delayed each for one pitch and then added up to produce the data sequence B (= b + jb - b - jb). In addition, data is added before and after this data sequence B to produce a finite-length periodic sequence. FIG. 1(d) shows a finite-length periodic sequence. As shown in FIG. 1(d), this finite-length periodic sequence is produced by adding the ending data sequence (jb) of the data sequence B to the start of the data sequence B (=b + jb - b -jb) and by adding the starting data sequence (-jb) of the data sequence B to the end of the data sequence B.

The intervals among the data sequences b, jb, -b, and -jb of the data sequence B can be determined arbitrarily according to the intervals among the coefficients of the sequence a (for example, T1, T2, …).

The spreading sequence can be produced by using a DFT matrix. FIG. 2 shows the coefficients of a fourth order DFT matrix.

The following describes an example of a spreading

sequence of a fourth order DFT matrix.

When the data sequence is (1, 0, 0, 0) and the coefficient sequences (1, 1, 1, 1), (1, j, -1, -j), (1, -1, 1, -1), and

==page 9==

For example, a data sequence of a finite-length periodic sequence A' can be produced by adding the ending data sequence (1, 0, 0, 0) and the starting data sequence (1, 0, 0, 0) of the periodic sequence A before and after the periodic sequence A.

A' = (1, 0, 0, 0, A, 1, 0, 0, 0)

The data length of this periodic sequence A' is the data length 16 bits of the periodic sequence A plus four bits on its both ends, that is, a total of 24 bits. This periodic sequence A' can be obtained by taking it out from the infinite periodic sequence (…AAAA…) of the periodic sequence A.

The transmission signal whose transmission data is the finite-length periodic sequence A' can be obtained by a matched filter (matched filter) corresponding to the coefficients of a spreading sequence used for the production of the transmission signal. A matched filter, a filter used for de-spreading and obtaining the transmission signal A, is produced corresponding to the coefficients of the spreading sequence used for the production of the transmission signal A.

The relation between the input signal and a matched filter is determined based on the complete complemetarity of the spreading sequence. For example, when the signal M is passed through the matched filter for the signal M, an impulse-like signal can be obtained due to the auto-correlation characteristics; however, when the signal M is passed through a matched filter other than the matched filter for the signal M, no signal can be obtained due to the cross-correlation characteristics.

Let Af be a matched filter for the signal A. When the signal of the periodic sequence A' is passed through this matched filter Af, the output of the matched filter Af can be represented by the convolution operation shown below. Note that, to maintain the processing compatibility in the matched filter Af, the periodic sequence A' is changed to (A', 1) to increase the signal length by 1 to 25 bits.

(A', 1)*Af = 16(x, x, …, x, x, 1, 0, 0, 0, 1, 0, 0,0, 1, 0, x, x, …, x, x)

==page 16==

P0-p3 can be obtained from the output of the matched filter Af for the signal A, and q0-q6 from the output of the matched filter Bf for the signal B.

As is apparent from the above description, the method according to the present invention includes transmission data into a spreading sequence to allow the whole signal, which includes the data, to function as a spreading sequence. This reduces an increase in the amplitude of the signal and reduces the dynamic range of an amplifier on the receiving side.

INDUSTRIAL APPLICABILITY

The transmission method, communication method, and the data structure of the transmission signal according to the present invention are advantageous to and useful for the multi-path environment of mobile communication.